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THE SHADOW TEST

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THE SHADOW-TEST.

THE
SHADOW-TEST

IN THE
DIAGNOSIS AND ESTIMATION OF AMETROPIA

BY
W. M. BEAUMONT
SURGEON TO THE BATH EYE INFIRMARY

JOHN JOHNSON

LONDON
H. K. LEWIS, 136 GOWER STREET, W.C.
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PREFACE.

In the following pages a general knowledge of the use of the ophthalmoscope, gained practically in the ophthalmic out-patient department of a hospital, is presupposed.

The optical explanation of the shadow-test, which would require illustrations for its elucidation, together with much theoretical and elementary detail, have been omitted with a view to make the book as practical as possible.

The treatment of ametropia, although touched on occasionally, is no part of the object in view.

W. M. B.

May, 1890.

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THE SHADOW-TEST IN THE DIAGNOSIS AND ESTIMATION OF AMETROPIA.

CHAPTER I.

INTRODUCTORY AND HISTORICAL.

THE method of testing the refraction of the eye by means of a certain shadow that can be produced by reflecting light from a mirror on to the retina, has received, and is known indiscriminately by many names—Keratotomy, Koroscopy, Skiascopy (Skiascopia), Pupilloscopy, Retinoscopy, Cuignet's method, and others have been suggested. Their number is evidence that these names are not perfectly satisfactory, and therefore until a designation that receives a more general imprimatur is introduced, it seems best to employ the compound English name of THE SHADOW-TEST. The word Keratotomy, applied by the discoverer of the method, is founded on the mistaken idea that the process in some manner depends on the refractive qualities of the cornea alone. Retinoscopy is objectionable from the fact that every investigation of the retina by means of the ophthalmoscope, whether for refractive or other purposes, may be fairly considered a retinoscopic observation. Koroscopy seems to have little to recommend it, and the same may be said of the nondescript

Græco-Latin term Pupilloscopy. Skiascopy (Skiascopia) has not found favour. "Cuignet's method" has the advantage of perpetuating the name of the introducer of the process.

The Shadow-Test is a method at once accurate and rapid for estimating the refraction and gauging the amount of ametropia, but at the outset it may be remarked that it should not be acquired too early in the student's career. It has the disadvantage of fascinating the attention away from the ophthalmoscopic appearances of the fundus oculi; it is in fact an art totally distinct from ophthalmoscopic science, and one requiring but the most elementary knowledge of the use of the ophthalmoscope. Nevertheless, it is an auxiliary of the utmost value, and to the student who has previously acquired the use of the ophthalmoscope in testing the vision by the direct method, it may be safely recommended without fear of its being abused. To the physician who makes no special study of ophthalmic science, the ease with which proficiency may be acquired renders the method of great service.

Compared with the direct method of testing the ametropia by means of the vessels, the shadow-test has several advantages. It is an objective method and therefore independent of the imagination of the observer. The shadow moves "with" or "against" the mirror, and there is no doubt about it. In the direct method the observer's accommodation may not be thoroughly relaxed; he may think the vessels are best seen with a + lens, when the refraction is really emmetropic. One observer may think the vessels are best seen with a - 4 D, another with a - 5 D, and so on. As Schweigger remarks on this

subject* :—"Whoever, for instance, is firmly convinced that convergent strabismus depends on hypermetropia, will, in doubtful cases, very easily carry his subjective conviction into the objective examination, and will still see clearly the fundus of even an emmetropic eye with a weak convex glass—the objective signs for the clearness of the image have no absolutely defined limits. But apart from this, other sources of error are possible. A person using the ophthalmoscope, for instance, who, without knowing it—and such a thing may happen—possesses a slight degree of latent hypermetropia, will find his own hypermetropia everywhere, just also as a myope, who deceives himself slightly about the degree of his myopia in the calculation of the ophthalmoscopic diagnosis of refraction, lays rather too high a value on his own myopia."

With the direct method too, unless an oblique mirror is used, the ophthalmoscope may not be held exactly parallel with the plane of the vessel under observation, and thus an error of some consequence may arise. Astigmatism may be diagnosed when none exists. The direct method is not reliable in myopia of more than 8 or 10 D, unless a meniscus be used.† Again, the direct method is sometimes difficult to apply at the yellow spot, from the sensitiveness of that part of the retina to light, and so the observer has to rely on the refraction of some other part of the fundus which may differ very considerably from that of the visual axis.

The shadow-test is invaluable in amblyopia, in cases of

* "Clinical Investigations on Squint," English translation, 1887, p. 13.

† Landolt, *op. cit.*, p. 259.

malinger, in hysterical women, in the weak-minded, in children and in the uneducated.

To Cuignet, of Lille, is due the credit of demonstrating the use of the shadow-test. It is singular that it should not have been utilized earlier in the evolution of ophthalmology, for many surgeons must have noticed the shadow, although they did not observe its significance. Sir William Bowman even went so far as to recognise the value of the shadow in the diagnosis of astigmatism, but he overlooked the fundamental principle of the varying direction of its movement according to the refraction of the eye. In his own words he has "been sometimes led to the discovery of regular astigmatism of the cornea and the direction of the chief meridians, by using the mirror of the ophthalmoscope much in the same way as for slight degrees of conical cornea. The observation is more easy if the optic disc is in the line of sight and the pupil large. The mirror is to be held at two feet distance, and its inclination rapidly varied so as to throw the light on the eye at small angles to the perpendicular and from opposite sides in succession, in successive meridians. The area of the pupil then exhibits a somewhat linear shadow in some meridians rather than in others*."

Again, in writing on Conical Cornea, Sir William Bowman says, that "soon after the immortal invention of Helmholtz, I found the ophthalmoscope very useful in detecting slight degrees of conical cornea. For this purpose the concave mirror only is to be used without a convex

* "On the Anomalies of Accommodation and Refraction of the Eye,"
Donders, English Edition, New Syd. Soc., 1864, p. 490.

lens. On turning the mirror so as to throw light at different angles, the side of the cone opposite to the light is darkened. Probably every one is now familiar with this test. Professor Donders told me last year that he had himself observed it. It is a very useful one in discriminating the cause of slight defects of vision, somewhat resembling myopia, and hitherto deemed anomalous.*

The credit of the discovery may be divided fairly between Bowman and Cuignet; the former first used and described it, the latter utilised and popularised it. Cuignet wrote about it in 1873, Bowman had observed it fourteen years previously. It was introduced to Parisian ophthalmologists in 1878 by Dr. Mengin, who had learnt it from Cuignet. Dr. Parent elaborated the method by applying lenses in front of the patient's eye to estimate the amount of error,† and he substituted the concave mirror for the plane one used by Cuignet.‡

In England there does not appear to have been any literature on the subject prior to Dr. Forbes's article in the tenth volume of the "Royal Ophthalmic Hospital Reports" (August, 1880). He was followed by Mr. Morton§ and Dr. Charnley||.

* "Ophthalmic Hospital Reports," vol. ii., p. 157, Dec. 1859.

† Landolt, "The Refraction and Accommodation of the Eye," English translation, 1886, p. 275.

‡ Juler, "Ophthalmic Review," vol. i., p. 328.

§ "Refraction of the Eye," 1881.

|| "Royal Ophthalmic Hospital Reports," vol. x., 1882.

CHAPTER II.

THE SHADOW-TEST IN GENERAL.

WHEN the light from a gas or oil burner is reflected by an ophthalmoscopic mirror into the normal eye, the fundus is seen to be illuminated, and if the mirror is rotated on its axis, a shadow, more or less visible, is seen to move across the pupil. This shadow is the test with which we are dealing, and its form, movements, distinctness and speed, are the details that have to be mastered in order that we may proceed to utilise its information. The beginner has also to learn how to neutralise this shadow, for neutralisation of the shadow and correction of the ametropia are practically convertible terms.

This shadow, the cause of which appears to have been misunderstood by Cuignet, is now known to be merely the dark margin surrounding the image of the light reflected into the patient's eye; and according to the position of this image, whether in front of or behind the nodal point of the eye under observation, will the shadow move when the mirror is rotated.

The shadow from which the Test gains its name is the darkness rapidly taking the place of the disappearing light, and the method might as accurately be described as the Light-Test. The position of the image varies according to the kind of refraction and according to the amount, that is qualitatively and quantitatively. A dull reflex (supposing there is no other condition of the eye inter-

fering with the transmission of light) and a slow moving shadow mean a high degree of error; a bright reflex and a quick moving shadow tell us there is but little error. The higher the error then the more difficult is it to see the shadow.

The *shape* of the shadow is said to vary with the amount of error, a linear shadow being commonly stated to be synonymous with a low degree of ametropia, whilst a crescentic one corresponds with a high degree. The student is not, however, advised to lay too much importance on the differentiation of the degree by means of the shape of the shadow.

In some forms of irregular astigmatism, such as in conical cornea, it is almost impossible to tell either the shape of the shadow or the direction of its movements. For a full optical explanation of the cause of the shadow the reader is referred to Dr. Charnley's classical exposition in the tenth volume of the "Royal Ophthalmic Hospital Reports."

With regard to the mirror, either a plane or a concave one may be used, but the shadow produced by the plane mirror will be found to move in exactly the opposite direction to that produced by the concave mirror, excepting only in very low degrees of myopia. Which mirror then shall we use? There are advantages and disadvantages connected with each. The plane mirror was used by Cuignet, and is preferred by many ophthalmologists. It is simpler in practice, and there are fewer exceptions to remember in its application, but it is rather more difficult for the beginner to throw the ray of light in the right direction, and it has the great disadvantage that

the observer should be seated more than four metres from the patient. This seems an almost insuperable objection against its use when many cases have to be tested. In astigmatism, where the shadow-test is most valuable, the walking backwards and forwards, by the surgeon, between those weary four metres, until like Bonnivard in Chillon "his very steps have left a trace" will occupy too much time. The exercise it has been suggested is good, but promenading in a room, with closed door and darkened window, lighted by gas or oil, is more tedious than hygienic, more monotonous than exhilarating.

With a concave mirror on the other hand the surgeon can seat himself comfortably at 120 cm. from the patient, that is within convenient distance for the various details to be carried out; the mirror is easier to manipulate and the light is less diffuse. For these and other reasons the concave mirror is preferred by most ophthalmologists. It should have a focus of not less than 25 cm. Messrs. Morton and Barrett recommend one of 36 cm. focal distance.*

The shadow produced by a concave mirror is seen to move in the same direction as the mirror (when this latter is rotated on its axis) in cases of myopia above 1 D, and in the opposite direction in cases of emmetropia or hypermetropia or very low myopia. These movements of the shadow are commonly spoken of as "with" or "against"

* "British Medical Journal," 1886, vol. i., p. 107.

If a plane mirror be employed it should be one of fully four cm. in diameter, and the sight-hole should be four mm. The shadow will move "against" the mirror in myopia, and "with" the mirror in emmetropia and hypermetropia.

the mirror. In the following pages, unless otherwise stated, it is to be remembered that it is the concave mirror that is used.

The surgeon should be aware of any ametropia that may exist in his own eyes before practising the shadow-test. Usually low degrees of hypermetropia and presbyopia may be left uncorrected, but high degrees as well as myopia or astigmatism should certainly be neutralised by a correcting lens behind the mirror.

The patient and the surgeon should be seated facing each other at a distance of 120 cm., so that their faces are as nearly as possible opposite and on the same level. The ordinary adjustable music stools are convenient for this purpose. The room is made quite dark, and an oil or gas light, with as small a burner as convenient, is placed either just above the patient's head or in the usual ophthalmoscopic position, on either side of and rather behind his head, so that the face is not illuminated. It is advantageous to have an opaque metal chimney surrounding the light with a circular aperture on one side, like a bull's-eye lantern without the lens, pointing towards the surgeon; by this means superfluous rays of light are cut off, the patient's face is quite in the dark, and a better defined illumination of the fundus is obtained.

Having carefully observed that there are no opacities of the cornea, lens, or vitreous, that keratoconus is not present, and that there is no disease of the retina, the patient is directed to look straight in front of him as though he were looking through the surgeon's head at the wall of the room behind. This is one of the most important points in the method, for if he look upwards or

downwards or to either side, an accurate result will not be obtained. It is more difficult to see the shadow when the patient looks straight, so that his visual axis is in a direct line with the observer's, especially if his accommodation has not been paralyzed, but with a little practice the difficulty can be overcome.

In no ophthalmoscopic observation, whether for the shadow-test or for ordinary observation of the disc (direct or indirect) should the patient be told to look at the observer's outstretched little finger or at the top of his ear unless the accommodation is thoroughly paralyzed; for looking at any object so near as the finger or ear means that the patient uses his accommodation, and accommodation and contraction of the pupil are convertible terms. To see the optic disc the patient should be directed to look over the surgeon's shoulder into distance.

As soon as the bright reflex of the fundus is observed, the mirror, which should have a sight-hole of not more than three or four mm., is revolved on its vertical axis, when a shadow is seen to appear apparently from behind the iris and move across the cornea, or it may be that the disc of light itself, rather than a shadow, seems to move. The shadow may move in the same direction as that in which we revolve the mirror, or it may move in exactly the opposite direction, or again it may appear to travel in an intermediate or oblique direction.

Suppose the mirror to be revolved from right to left and the shadow move in the same direction, the refraction of that meridian may unhesitatingly be known to be myopic. If on the other hand the shadow move in the opposite direction the refraction is either emmetropic, hypermetropic

or less than 1 D myopic. We must now proceed to find out which we have to deal with. If the reflex is dull and the shadow moves slowly, the case is one of high hypermetropia, but suppose the reflex to be bright and the shadow quick moving, we put a trial-frame containing a lens $+0.5$ D in front of the eye under examination (the other eye being excluded by an opaque glass). If the shadow is now found to move "with" the mirror, the eye is myopic to a degree not exceeding 1 D. But if the shadow still move against the mirror the lens is changed for one of $+1$ D. If this is sufficiently strong to give a shadow "with" the mirror, the eye is emmetropic; if it is not sufficiently strong to do so the eye is hypermetropic. This seems a little complicated at first but is soon mastered, it is in fact the strong point urged by advocates of the plane mirror, with which it is easier to remember that if the shadow move "with" the mirror the case is one of emmetropia or hypermetropia, and if it move "against" it is one of myopia.

For physicians and others who wish to test the vision qualitatively but not quantitatively, and who therefore do not wish to obtain a case of trial lenses, it is convenient to have a pair of reversible spectacles fitted with a $+1$ D in one eye frame, and a $+0.5$ D in the other. With this, together with a Galezowski mirror, which can be obtained from the optician for a small price, the nature of the refraction, but not the amount, can be known in any case, and the patient can then be sent on to the ophthalmic surgeon for spectacles if necessary.

It was stated (p. 9) that the patient should be told to look straight in front when the shadow-test is being ap-

plied. The importance of this can be readily demonstrated by comparing the result obtained when the patient looks straight, with that obtained when he looks for instance to the right or left. Messrs. Morton and Barrett have drawn attention to the difference between the refraction of the macula and that of the optic disc,* and it will be found that there is still more variation in many cases between the refraction of the macula and the refraction of that part of the retina which is as far away from the yellow spot as can conveniently be tested. For instance, an emmetrope may be told to look over the surgeon's head in the direction of the ceiling; it is not improbable that his refraction will now be found to be apparently myopic if examined by the shadow-test. A myope who is directed to look as far to his right or left as possible may then have a hypermetropic shadow; or again a hypermetrope who looks down on the floor (the surgeon raising the upper lid) may present a myopic refraction.

To test the difference in the refraction at varying points of the retina, a number of patients were examined under atropine. First the refraction at the yellow spot, what may be called the visual refraction, was noted, and then the patient was directed to look successively, (i.) as far as possible to his right; (ii.) as far as possible to his left (inwards and outwards respectively); (iii.) upwards, and (iv.) downwards, and in each direction the shadow-test was applied. The result of these investigations showed that the refraction of different points of the retina, suppos-

* "A Clinical Investigation of the merits of various methods of practising Retinoscopy."—*Brit. Med. Journ.*, 1886, vol. i., p. 105.

ing these to have been true (so-called) keratoscopic shadows, varies within wide limits.

The results are tabulated as follows, the amount of error being omitted, and only the direction of the shadow noted.

TABLE I.

25 Cases of Emmetropia (*V. under atropine* = $\frac{2}{3}$).

	When the patient looked :			
	OUTWARDS.	INWARDS.	UPWARDS.	DOWNWARDS.
Percentage of cases in which the shadow moved with the mirror	76	68	0	0
Percentage of cases in which the shadow moved against the mirror	24	32	100	100

TABLE II.

50 Cases of Hypermetropia (*from 1 to 10 D*).

	When the patient looked :			
	OUTWARDS.	INWARDS.	UPWARDS.	DOWNWARDS.
Percentage of cases in which the shadow moved with the mirror	64	58	6	0
Percentage of cases in which the shadow moved against the mirror	36	42	94	100

TABLE III.

25 Cases of Myopia (from .75 to 12 D).

	When the patient looked :			
	OUTWARDS.	INWARDS.	UPWARDS.	DOWNWARDS.
Percentage of cases in which the shadow moved with the mirror	72	68	56	8
Percentage of cases in which the shadow moved against the mirror . . .	28	32	44	92

Whether a true shadow is obtained through an obliquely directed cornea or not, is not of much importance, the practical point is this, that unless the patient looks in the proper direction the result will not be reliable.

CHAPTER III.

MYDRIATICS AND THE SHADOW-TEST.

If absolutely accurate results are required the patient's accommodation must have been previously paralyzed by atropine or some other mydriatic before applying the shadow-test; and for learning its details it will be found much easier for the student at first to choose cases in which the pupil is fully dilated. But a paralyzed accommodation may be a serious inconvenience to the patient who has to earn his daily bread, and this point therefore should be duly considered before the atropine is instilled. Neither should the surgeon forget to explain to the patient that he will have this difficulty, especially in near vision, for several days. The omission of this explanation is a frequent cause of needless apprehension on the part of the patient, and of annoyance to the surgeon. Sometimes the difficulty may be got over when the ametropia appears to be equal in the two eyes by paralyzing one only, and then *ex uno disce ambo*, or the second eye may be paralyzed later on when the first has recovered its tone. Sometimes a suitable day may be selected for the particular case. For instance, Saturday afternoon, a clerk having finished his week's work, may have his accommodation sufficiently paralyzed by homatropine and the sight tested, and then be able to return to his office on the Monday morning, especially if only one eye is done at a time. A musician

would not thank you for paralyzing his accommodation the day before a concert; and Saturday is not the best day for instilling atropine in the eyes of a clergyman who has Sunday duty to perform. In middle-aged and old persons it must not be forgotten that there is a danger of inducing glaucoma by the injudicious use of atropine.

Let it be remembered that the total amount of error of refraction is the premiss from which is deduced the proper lens for its correction; to find out exactly what this amount is by the shadow-test the accommodation must be paralyzed. It does not follow from this that we must use a mydriatic for every patient who comes to us suffering from hypermetropia or myopia, for it is not generally necessary to know positively within a diopetre what the error is. But in all cases where spectacles have failed to relieve the symptoms, or where there is no opportunity of seeing the patient again, or where there is a suspicion of latent astigmatism, it is absolutely essential that the surgeon should have recourse to a thorough examination of the refraction. In young children it is safest to make a rule of paralyzing the accommodation; it simplifies the details, renders the operation quicker, easier and more certain, and makes us independent of their co-operation. With a little tact they can often be tested whilst asleep.

Landolt seldom finds it necessary to "have recourse to atropisation for the determination of astigmatism,"* but it must be remembered that he does not usually employ the shadow-test.

The use of mydriatics is imperative in some cases then,

* *Op. cit.*, p. 310.

it is convenient in most, it is unnecessary in others, and dangerous in a few. To know when to resort to them in the shadow-test requires some judgment. It will be found that without them the result may be an error of as much as 4 or 5 D, this is sufficient reason for employing them whenever practicable. The objection to their use would be stronger were it repeatedly necessary to examine a patient's refraction; but when it is remembered that the necessity of testing for spectacles arises but seldom in a patient's life, it is worth while when it is done that it should be carried out thoroughly and accurately.

In some cases where the refraction has been tested without atropine, the amount of error has been found to vary as much as one dioptré in successive examinations of the same eye, conducted too after very short intervals on the same day. This is probably accounted for by accommodative action of the ciliary muscle, by changes in the distance intervening between the surgeon and the patient, and by slight alterations in the direction in which the latter directs his eye.

Hitherto atropine has been spoken of as though it were the only recognised mydriatic, but as there are several drugs that are capable of producing the same effect it is necessary to consider briefly which is the best one to use for the shadow-test.

Sulphate of duboisia (gr. i. or ii. ad $\frac{3}{4}$ j.) is sometimes used to paralyze the accommodation. It has the advantage of doing this quickly, but several cases are on record in which it has produced alarming symptoms of collapse.*

* Simeon Snell, "Ophthalmic Review," vol. i., p. 340.

Hyoscine solution one-tenth per cent. is said to be more rapid in its effect and more manifest on the iris and the accommodation than atropine, but it is rather expensive.

Salicylate of atropine is recommended by Landolt, but is difficult to obtain.

With regard to cocaine the pupil is said to dilate more energetically from atropine when cocaine has been previously instilled into the eye than when atropine alone is used. Cocaine produces a wider dilatation than any other mydriatic.* It dilates the pupil, but has very little paralyzing effect on the accommodation, this property making it extremely useful for ophthalmoscopic purposes but not for ophthalmometric.

Hydrobromate of homatropine (gr. iv. ad $\frac{3}{4}$ j.) is generally stated to act more quickly than atropine,† its effects certainly pass off more rapidly.

To test the comparative value of homatropine and atropine twenty-five patients were selected whose pupils it was necessary to dilate for ophthalmoscopic purposes. Into the right eye of each patient one drop of solution of sulphate of atropine (gr. iv. ad $\frac{3}{4}$ j.), and into the left eye one drop of hydrobromate of homatropine of the same strength were instilled. The eyes were inspected at varying intervals during an hour and a half. In one case the dilatation of both eyes was equal, but in all the others the right iris dilated more than the left. The experiments were confined to the action on the iris, the effect on the accommodation was not investigated. These results are

* E. Jackson, "Ophthalmic Review," vol. vii., p. 222.

† Landolt, *op. cit.*, p. 567. Nettleship's "Students' Guide to Diseases of the Eye," 4th edit., 1887, p. 425.

entirely at variance with the usual statement, viz., that homatropine acts more quickly than atropine.

The effects of atropine on the pupil were found to be rendered more rapid by combining it with cocaine.

Again twenty-five patients were taken, and into the right eye atropine was instilled, and into the left atropine combined with hydrochlorate of cocaine (gr. v. ad $\bar{3}$ j.). The cases were watched as before, and in every case the left pupil was found to dilate more than the right. This result is in accordance with the accepted opinion, viz., that cocaine increases the effect of atropine.

For shadow-test purposes the combination is to be recommended when it is required to dilate the pupil rapidly.

Formula for refraction drops:—

℞ Sulphate of Atropine, gr. iv.
Hydrochlorate of Cocaine, gr. v.
Boracic Acid, gr. x.
Distilled Water, $\bar{3}$ j.

The investigation of the refraction being completed, a drop of solution of sulphate of eserine (gr. ii. ad $\bar{3}$ j.) may be dropped in the eyes. This will to some extent counteract the mydriasis of the cocaine, although it will have very little effect on that of the atropine.

If the accommodation has to be thoroughly paralyzed by an instillation continued for several days, there is no special advantage in combining the two drugs, it will be found sufficient to order the atropine alone.

After thorough paralysis of the accommodation by atropine it often takes fourteen days for the effect to

completely pass away and for the ciliary muscle to regain its tone. If homatropine be used, three or four days should be allowed.

CHAPTER IV.

EMMETROPIA AND THE SHADOW-TEST.

EMMETROPIA may be regarded as the narrow line which divides hypermetropia from myopia; the border which separates the haven of the former from the pit-falls of the latter, the no-man's land in which vision is injured by plus as well as by minus lenses. If, however, the accommodation is not paralyzed, distant vision may be improved by low minus spheres and the near vision by low plus ones. Emmetropia is the most unusual condition of the Refraction although it is probably not so rare as some think. It is to be remembered that the emmetropes do not usually come to the out-patient department unless there is some anomaly other than the refraction affecting their eyes, for the "whole need not a physician but they which are sick." It is nevertheless a condition of the refraction too dangerously near myopia to be desirable.

The shadow-test gives a bright reflex, and a linear shadow "against" the mirror, frequently it appears as though the illuminated area, rather than the shadow, moved in the opposite direction to that in which the mirror is revolved. Under atropine the shadow will be found to be reversed by a $+1$ D lens, that is to say, it will now move "with" the mirror. To diagnose emmetropia by the shadow-test it is necessary to paralyze the accommodation. In 19 cases in which the refraction appeared to be emme-

tropic before atropine was used, it was found afterwards that 5 only were really so; of the rest 11 were hypermetropic (+ 1.25, 4.5, 3, 1.5, 4.5, 5, 2, 1, 1, 2.25, 1.25 respectively) and 3 were myopic (- .5, 1.5, 1.25 respectively).

Of 10 cases of emmetropia (vision atropized = $\frac{9}{10}$) 5 gave an emmetropic shadow when the accommodation was not paralyzed, 1 gave a hypermetropic and 4 a myopic.

An emmetropic refraction in young children who have a strong family history of myopia should be watched carefully, and the parents should be warned of the danger of its progressing onwards to a pathological condition. Strict instructions should be given with regard to education; small print, long hours and close application to books, feeble, artificial and ill-directed illumination should be avoided. The general health should be attended to and out-door games insisted on. Long distance vision should be educated, till the dangerous period of the child's schooling is well passed, and the refraction of the eyes has declared itself stationary.

It would perhaps be best to consider very slight deviations from emmetropia as normal, such as less than + 1 D on the one hand, and less than - 1 D (*in non-progressive cases*) on the other. Correcting lenses should never be ordered unnecessarily. A slight amount of hypermetropia is not usually troublesome, and unless it gives rise to symptoms may generally be left alone; the same rule applies but with more careful supervision to degrees of myopia of less than 1 D. For a slight degree either of hypermetropia or myopia as Landolt remarks* does not render an eye

* Landolt, *op. cit.*, p. 333.

pathological. We have no right to condemn a patient to spectacles for life without sufficient reason.

Errors of Refraction are very much commoner than is usually supposed. A very large number of the patients who come to our ophthalmic hospitals for advice come in consequence of some form of ametropia. Of 2000 successive patients 555 were found to be suffering either from Hypermetropia (305 cases) or Myopia (106 cases) or Astigmatism (144 cases). The comparatively large number of astigmatics is probably due to the fact that many myopes and hypermetropes never come to the ophthalmic surgeon at all, but rest satisfied with the "correction" of their ametropia made by an optician; astigmatics, however, he usually considers beyond the flight of his imagination, and so he sends them on to the ophthalmic surgeon.

CHAPTER V.

HYPERMETROPIA AND THE SHADOW-TEST.

HYPERMETROPIA (Hyperopia) may be considered the normal condition of babies, it is the refraction of most savage races, of congenital deaf-mutes* and of the lower animals. It is an arrest of development that to some extent becomes remedied with growth in the higher races, but remains permanent in the lower. But at all ages it is the most common condition of the refraction. Usually it is due to a congenital flattening of the eye, the visual axis is too short, but it may exceptionally be caused by a sub-normal convexity of the cornea or by a decrease in the index of refraction of the aqueous. It is not then a pathological but rather a developmental condition, and in most cases is capable of neutralization by an unconscious act of accommodation. Only when this act of the ciliary muscle gives rise to symptoms may it be considered pathological.

Investigations of the refraction of new-born children by Dr. Horstmann, of Berlin† show that amongst 50 babies there was only one myope, whilst Königstein, who examined 300 new-born children, did not find one. Jaeger on the other hand found 78 per cent. of myopes. His experiments which were made about 30 years ago are certainly not in

* Desjardins, "Ann. d'oculis," t. lxxxiv., p. 103.

† "Ophthalmic Review," vol. iii., p. 375.

accord with recent investigations. Presumably they were carried out by the direct method and he did not use atropine.

It will be found practically that somewhere about 1 or 1.5 D of hypermetropia is the commonest condition of the refraction, and in many respects it is the most satisfactory. It is sufficiently removed from myopia to give no alarm of invasion from that pathological state ; distant vision is not inconveniently (if at all) interfered with, and near vision does not commonly suffer unless very great demands are made on the accommodation or unless this latter is weakened by an exhausting disease. Only will the age of presbyopia be somewhat anticipated. It is the refraction of many of our best tennis players, cricketers and billiard players.

It is not usually necessary to paralyze the accommodation in using the shadow-test in hypermetropia, for although the full amount is not generally found yet on the other hand the result does not often exceed the total hypermetropia. Glasses may be prescribed for close work coinciding as nearly with the shadow-test (but not exceeding it) as will enable the patient to read J 1 comfortably at 33 cm. If more Hypermetropia becomes manifest later on the spectacles can then be increased in strength, or a full investigation under atropine can then be made.

If there is the slightest tendency to convergent strabismus the accommodation must always be paralyzed before applying the shadow-test ; and so important is the *early treatment* of this disease that the sun should not be allowed to go down before it is commenced. It is usually very much easier to satisfy the public than it is to satisfy one's own conscience in the matter, for anybody can perform a

tenotomy, but it requires prolonged patience and protracted perseverance to cure a squint.

THE SHADOW-TEST.—In hypermetropia, although not usually essential, it is more satisfactory to paralyze the accommodation; the test is then easier to apply and more accurate. Cover the eye that is not being examined and tell the patient to look straight in front. The shadow will be seen to move "against" the mirror; if the reflex is dull and the shadow move slowly, showing a high amount of error, place a + 5 D in the spectacle frame, and if now the shadow is still "against" exchange it for a + 7 D. Practice will soon teach what power is likely to be required and it is only wasting time to replace the lenses half a diopetre at a time when there is a probability of a high refractive error. As soon as the hypermetropia is seen to be over-corrected, the shadow moving "with" the mirror, go back a diopetre until *the strongest + glass is found which still gives a shadow against the mirror, this glass (or a little less) is the measure of the hypermetropia.*

In prescribing glasses for old people it must not be forgotten to add on in addition the necessary correction for presbyopia; but in all cases it is much more satisfactory to let the patients come again after the mydriasis has passed off. It is doubtful work ordering spectacles by rule; some patients require more of their latent hypermetropia neutralized than others, and if the glasses are to be of service some allowance must be made for individual idiosyncrasies.

In 68 hypermetropic eyes tested by the shadow-test it was found that the average error amounted to 3.55 D with the accommodation not paralyzed; the same eyes after the

accommodation had been paralyzed, yielded an average of 4.09 D for each eye. This does not seem much difference in the aggregate, but unfortunately individuals cannot be supplied with spectacles by the doctrine of averages any more than they can be fitted with hats or boots on the same principle. In some cases there was found to be as much difference as 4 D between the refraction of the unparalyzed, and that of the paralyzed accommodation. Of the 68 eyes, in 9 the refraction was the same before and after atropine. There was an increase in the amount of hypermetropia after atropine 51 times, and a decrease 8 times. One hypermetrope with 2.75 of total error appeared to have when the accommodation was not paralyzed a myopia of 1 D.

CHAPTER VI.

MYOPIA AND THE SHADOW-TEST.

MYOPIA is sometimes spoken of as though it were the converse of hypermetropia, but it must not be lost sight of, that whereas the latter is usually a congenital malformation or an arrest of development and stationary, the former is not infrequently a pathological condition, of which the myopia is merely a symptom, requiring watchful treatment and circumspection to prevent its progress.

Progressive myopia is too serious a disease to be placed in antithesis with hypermetropia ; it is the difference between a photographic camera that is out of focus, and one in which the sensitive plate is cracked as well as out of focus.

Myopia is said to be the normal refraction of fish.*

In the human species it is extremely rare in infancy, and only later on in life when accommodation begins to be actively employed for near vision is it that the tendency (especially in those with hereditary predisposition) is developed. It calls for treatment early not only for correction by lenses but also, and this is equally important, by hygienic measures and by abstinence from close study. The myope gropes about in a smaller world than his emmetropic and hypermetropic brethren, and his tendency

* Hirschberg, "Ophthalmic Review," vol. ii. p. 155.

is to find his pleasure in books and his occupation in sedentary pursuits, and so the vicious circle is formed.

The amount of light and its direction are important considerations in the treatment of myopia. There is no doubt that the present fashion of dimly lighted rooms is bad for the short-sighted; the light should be good but well diffused, artificial illuminants should approach as nearly as possible to the condition of day-light. Dazzling electric and gas-jets should be avoided, and the sum of brightness made up by a number of less intense points so situated that there is no direct glare upon the eyes. At present the electric illumination is too scintillating and too variable to be recommended for rooms, but we may look forward confidently to its perfection, and then we shall have at our disposal a light second only to the sun itself.

Certain races, such as *e.g.* the German, appear to have a much stronger tendency towards myopia than others. That this is at least as much due to racial as educational causes seems to be shown by the fact that a people so cosmopolitan as the Jewish have also a marked predisposition to myopia.*

THE SHADOW-TEST.—Fortunately myopia is a rarer condition of the refraction than hypermetropia. To get an accurate knowledge of the amount of myopia by the shadow-test it is essential that the accommodation should be paralyzed; otherwise we shall sometimes find that the fatal mistake has been made of over-correcting the error of refraction, it may be by as much as 1 or 2 D. The details of the test are similar to those for hypermetropia.

* "Hygiène de la Vue," par Galezowski et Kopff, p. 66, 1888.

The shadow moves "with" the mirror unless the error is less than 1 D when it moves "against." Suppose a + 0.5 D lens reverses the shadow the amount of error then may be considered equal to - .5. If the reflex is dull and the shadow responds slowly to the mirror, its movement being in the same direction, a high amount of myopia may be diagnosed. Commence then by placing a - 8 D in the trial frame before the patient's eye, if the shadow is still "with" the mirror, continue successively with - 10 D, - 12 D, - 14 D, Suppose the shadow to become "against" the mirror when we have arrived at - 14 D, go back a dioptré to - 13 D, and if now the shadow is "against" the mirror, this may be considered the correcting glass. The rule may be stated to be that *the weakest - lens which gives a shadow "against" the mirror is the measure of the myopia.*

In 50 cases of myopia examined by the shadow-test both before and after the use of atropine, it was found that the refraction was the same in 18; the amount of myopia was increased after atropine in 18, and diminished in 14.

CHAPTER VII.

ASTIGMATISM AND THE SHADOW-TEST.

REGULAR astigmatism is usually due to a congenital ellipsoid, instead of globular, shape of the globe, the fault being mostly with the cornea. It may be diagnosed by the shadow-test when (I) the shadow moves "with" the mirror in one meridian and "against" the mirror in the meridian at right angles; (II) when the shadow appears to move obliquely to the direction in which the mirror is revolved; (III) when the shadow moves more quickly in one meridian than it does in the opposite. Sometimes when there is no great amount of astigmatism it cannot be diagnosed until correcting lenses have been placed in front of the eye under examination.

Occasionally the shadow appears to start from the centre of the cornea and to move partly in one direction and partly in the opposite, so that it is difficult to say whether it is moving "with" or "against" the mirror. This should always raise the suspicion of irregular astigmatism caused by keratoconus or opacity of the cornea, both of which conditions give rise to a shadow that may be mistaken by a careless observer for that of regular astigmatism.

Patients whose principal meridians are oblique usually complain much more of bad sight than those whose principal meridians are horizontal and vertical, the reason for this being that objects both in nature and art are much

more frequently horizontal or vertical than oblique in direction.

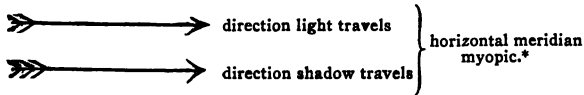
In all cases of astigmatism tested by the shadow-test it is absolutely essential that the accommodation should be paralyzed. The cornea is the commonest seat of astigmatism, and a large amount of it may be compensated by the action of the accommodation, and only become manifest when the ciliary muscle can no longer act. In some cases the accommodation causes an apparent astigmatism where none really exists; or again the meridian which appears to be the one of greatest refraction may, after atropine has been instilled, be shown to be the one of least refraction.* The greatest amount of astigmatism usually exists in those cases in which the cornea has been scarred, as for instance by an operation for cataract.

As astigmatism is so much dependent on congenital formation of the cornea it is not surprising to find that this form of error of refraction is not usually a progressive one; it may, and in cases of traumatic astigmatism, such as that following an operation for cataract, frequently does diminish in course of time.

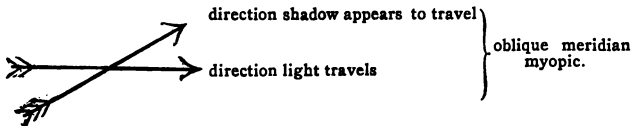
THE SHADOW-TEST.—The patient's eyes being thoroughly atropized, the test is applied in a similar manner to that already described, and in the first place it is noticed whether the *direction* of the principal meridians can be diagnosed by the movement of the shadow. This can almost always be done at a glance in cases of mixed astigmatism, in simple myopic astigmatism and in cases of simple hypermetropic astigmatism of high degree. In compound astigmatism in which there is no great difference in the opposite

* Landolt, *op. cit.*, p. 302.

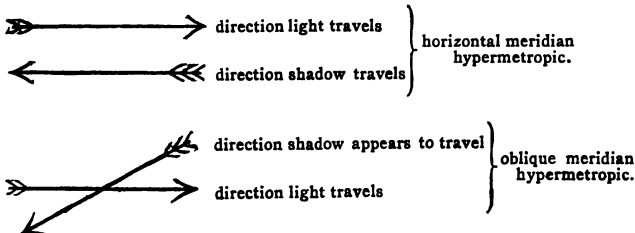
meridians, it is not quite so easy until a part of the astigmatism is neutralized by lenses placed in front of the eye. Suppose the mirror to be revolved on its vertical axis so that the light travels horizontally across the cornea, if the shadow is seen to move in exactly the same direction the horizontal meridian is known to be myopic.



But if (instead of moving exactly in the same direction as the light is made to travel) the shadow move (apparently) in a diagonal course the principal meridians are then known to be oblique.

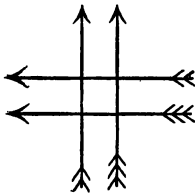


If these same meridians are, however, hypermetropic, we shall then get the shadow moving in the opposite direction thus:—

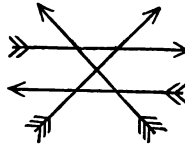


* In these and the following instances emmetropic and low myopic refraction are for simplicity omitted.

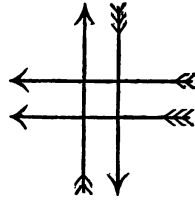
If we now add the meridians at right angles, representing the shadow by a three-barbed arrow, and the light by a two-barbed, we shall then get the following diagrams in the different forms of astigmatism.



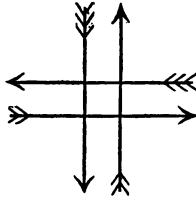
Comp. M. As. Meridians horizontal and vertical.



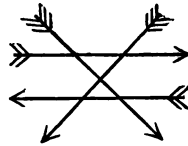
Comp. M. As. Meridians oblique.



Mixed As. Horizontal Meridian M. Vertical Meridian H.



Comp. H. As. Meridians horizontal and vertical.



Comp. H. As. Meridians oblique.

In estimating the amount of error by the shadow-test in cases of astigmatism, it is well to have a systematic rule as to the order in which the investigation is carried out. It will be found convenient always to take first the right eye, beginning with the horizontal meridian or that which most nearly approaches to it. Having found the correcting lens by the same method as that described under hypermetropia and myopia, make a note of it at once. Suppose -4 D to be the amount of myopia discovered in

the horizontal meridian it is roughly noted on paper, thus, $+ -4$. The vertical meridian is then examined; let this be $+ 2$ D this number is then entered against the vertical arm of the rough diagram which then reads $\begin{matrix} + -4 \\ + 2 \end{matrix}$. Had

the meridians been oblique they would have been represented thus $\times \begin{matrix} -4 \\ + 2 \end{matrix}$. The exact degree of obliquity will be

discovered when the result of the shadow-test is confirmed later on by placing correcting lenses in the astigmatic trial-frame, and observing accurately the exact axis which gives the best vision for the distant type. Having found the correcting lenses for the right eye, the process is repeated for the left. Suppose in this case the meridians are oblique and respectively emmetropic and $- 3$ D it will then be noted thus $\times \begin{matrix} -3D \\ em \end{matrix}$.

The patient is now placed at 6 metres from the test-types, and the result of our investigation confirmed. For the Right eye a $+ 2$ D spherical lens is put in the trial frame, this will correctly neutralize the vertical meridian but at the same time will add on $+ 2$ to the horizontal meridian where it is not wanted—so to get rid of its effect we take a $- 6$ D cylinder and place it in the trial frame in front of the sphere with its axis vertical; of these $- 6$ D 2 D will go to neutralize the horizontal portion of the plus sphere, and the other 4 D to correct the ametropia. This combination may now be placed in front of the patient's Right eye when it may be found necessary to make some slight alteration to get the best possible vision, the usual indication being towards slightly reducing the plus, and rather increasing the power of the minus lenses.

but in the majority of cases no alteration will be necessary. For the Left eye it will only be necessary to place a -3 D cylinder in the frame and revolve it in front of the patient's eye until the position is found in which it gives the most perfect vision.

It is safest not to order spectacles from the results arrived at when the accommodation is paralyzed for the reason assigned when discussing hypermetropia (p. 26). Patients will not wear spectacles even though vision is greatly improved by them, if at the same time the glasses cause some slight discomfort or if after wearing them for some hours they produce headache. The patient may be dismissed to return again in a fortnight, so that the ciliary muscle may regain its tone before the spectacles are prescribed. It will then probably be found that the hypermetropic meridians require considerable reduction in the power of the correcting lens, whilst the myopic meridians will call for nearly or quite the full correction, but as the treatment of errors of refraction is beyond the scope of the shadow-test, which only lays down the foundation on which the treatment is based, it is unnecessary to follow the case further.

The vertical meridian of the cornea, it is worth remembering in using the shadow-test, is generally the most convex that is the most myopic, or least hypermetropic,* but exceptions are very frequent, as will be seen from the

* Landolt, "Refraction and Accommodation of the Eye," Eng. trans., 1886, p. 300.

Swanzy, "Diseases of the Eye," 2nd edit., 1888, p. 38.

Berry, "Diseases of the Eye," 1889, p. 482.

following statistics; and the opposite is said by Javal to be the rule with Jews. Astigmatism of less difference than 1 D between the principal meridians may usually be disregarded, and the case treated by spherical lenses alone.

Of 194 cases of regular astigmatism 66 were myopic (simple 60, compound 6), 102 hypermetropic (simple 23, compound 79) and 26 mixed. In these 194 cases the principal meridians were vertical and horizontal 131 times, and oblique 63 times.

In the 66 cases of myopic astigmatism the meridian of least error was found to be:—

Horizontal in 51·51 per cent. of the eyes.

Vertical in 27·27 " " "

Oblique in 21·21 " " "

In the 102 cases of hypermetropic astigmatism the meridian of least error was found to be:—

Horizontal in 6·86 per cent, of the eyes.

Vertical in 57·84 " " "

Oblique in 35·29 " " "

The following table shows the average vision in astigmatic eyes with correcting lenses. No case is included in which there was found to be strabismus or opacities of the media, and cases of astigmatism after cataract extraction are also excluded:—

In 4 cases of Simple Myopic Astigmatism the average vision was equal to $\frac{6}{8}$.

In 55 cases of Compound Myopic Astigmatism the average vision was equal to $\frac{6}{18}$.

In 17 cases of Simple Hypermetropic Astigmatism the average vision was equal to $\frac{6}{18}$.

In 72 cases of Compound Hypermetropic Astigmatism the average vision was equal to $\frac{6}{18}$.

In 23 cases of Mixed Astigmatism the average vision was equal to $\frac{6}{18}$.

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